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Indian Standard

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सिंथेसाइज्ड हाइड्रोकार्बन युक्त एविएशन टर्बाइन ईंधन (मिट्टी के तेल के प्रकार, जेट ए-1) — विशिष्टि

Aviation Turbine Fuel (Kerosene Type, Jet A-1) Containing Synthesized Hydrocarbons — Specification

ICS 75.160.20

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Petroleum and their Related Products of Synthesis or Biological Origin Sectional Committee, PCD 03

FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards, after the draft finalized by the Petroleum and their Related Products of Synthesis or Biological Origin Sectional Committee had been approved by the Petroleum, Coal and Related Products Division Council.

Aviation turbine fuel, kerosene type, Jet A-1 fuel (IS 1571) consists predominantly refined hydrocarbons derived from conventional sources including crude oil, natural gas liquid condensates, heavy oil, oil shale and oil sands. Use of synthesized fuel components from alternate renewable sources is envisaged to decrease net lifecycle carbon emissions. Hence, the formulation of this new standard is taken up to cover the manufacture of aviation turbine fuel that consists of conventional and synthetic blending components.

Research and development work is being carried out all over the world in the area of synthetic components derived from renewable sources. Indigenously, Indian Institute of Petroleum (IIP) of Council of Scientific & Industrial Research (CSIR) has developed a technology for synthesizing hydrocarbons from esters and fatty acids using hydroprocessing technology (Refer CSIR-IIP report HA/CCD/2018/Bio-ATF-157). The research work is available in technical project report reference number: ICRD08-054, titled “Applications of Biofuels for Aviation” a joint project between ISTP Canada — Pratt & Whitney Canada (P&WC), GITA and Infotech enterprises. CSIR-IIP’s process control document no.: HA/CCD/2018/Bio-ATF-157 discusses the process, and the test results of the bio-jet fuel produced from the hydroprocessing of esters and fatty acids for the production of hydrocarbons. Test flight with Bombardier Q400 Aircraft of SpiceJet Ltd., powered with a blend of 25 percent of this Bio-Jet fuel in right engine was carried out. The Committee while preparing the standard considered this synthetic fuel, among others.

The need for International Coordination among recognized standards of other countries on the subject is particularly significant for the product of this type, since re-fueling of aircraft in different countries is often involved. Hence this standard is aligned with British Ministry of Defence specification DEF STAN 91-091 (Issue 9, 03 October 2016) and ASTM specification for Aviation Turbine Fuel Containing Synthesized Hydrocarbons D7566 – 18 and shall be revised whenever needed, to align with the international specifications and practices. Assistance has also been derived from ASTM D 1655-18, Aviation Fuel Quality Requirements for Jointly Operated System (AFQRJOS-Issue 29 – Oct 2016).

The use of synthetic blends represents a departure from experience and from some of the key assumptions on which the requirements of this standard have so far been based. The specifications have now been made for hydrocarbon products obtained from alternative synthesis routes. While the use of synthesized hydrocarbons is known and an acceptable practice globally, the use of synthesized hydrocarbons from new sources requires specific guidance that is currently outside the scope of IS 1571 ‘Aviation turbine fuel, kerosene type, Jet A-1 — Specification’. This specification has been developed by the ‘Panel for Bio-Jet Fuels, PCD3:1/P-2’ (Annex K). Approval of synthetic components, processes and blends is the prerogative of the Regulatory Authorities namely, CEMILAC for defence, and DGCA for others, Aircraft and engine manufacturers as per applicable guidelines given in ASTM D4054.

For the purpose of deciding whether a particular requirement of this standard is complied with the final value, observed or calculated, expressing the result of a test or analysis shall be rounded off in accordance with IS 2 : 1960 ‘Rule for rounding off numerical values (*revised*)’. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

AVIATION TURBINE FUELS (KEROSENE TYPE, JET A-1), CONTAINING SYNTHESIZED HYDROCARBONS — SPECIFICATION

1 SCOPE

1.1 This standard prescribes requirements and the methods of sampling and test for synthetic blending components as well as aviation turbine fuel, kerosene type, Jet A-1 containing synthesized hydrocarbons for use in aircraft gas turbine engines designed to operate on such fuel.

1.2 This specification covers the manufacture of aviation turbine fuels that consists of conventional and synthetic blending components in the specified ratio.

1.3 This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

2 REFERENCES

The following standards contain provisions which, through reference in this text, constitute provisions of this standard. At the time of publication the editions indicated were valid. All standards are subject to revision, and parties to agreements based on the standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below:

IS No.	*Title*
1260 (Part 1) : 1973	Pictorial marking for handling and labeling goods: Part 1 Dangerous goods
1447(Part 1) : 2000	Petroleum and its products — Methods of sampling: Part 1 Manual sampling
1448	Methods of test for petroleum and its products:
[P : 3] : 2007/ ISO 2977 : 1997	Aniline point
[P : 6] : 1984	Calorific value by bomb calorimeter method
[P : 11] : 2004/ ISO 3013 : 1997	Petroleum products — Determination of freezing point of aviation fuels
[P : 15] : 2004/ ISO 2160 : 1998	Petroleum products — Corrosiveness to copper — Copper strip test
[P : 16] : 2014/ ISO 3675 : 1998	Density of crude petroleum and liquid petroleum products by hydrometer method
[P : 18] : 1991	Distillation of petroleum products
[P : 19] : 2015/ ISO 5275 : 2003	Detection of thiols and other sulphur species — Doctor test (*second revision*)
[P : 20] : 1998	Determination of flash point by abel apparatus
[P : 23] : 2004/ ISO 3837 : 1993	Liquid petroleum products — Determination of hydrocarbon types — Fluorescent indicator adsorption method
[P : 25/Sec 1] : 2018	Transparent and opaque liquids, Section 1 Determination of kinematic viscosity and calculation of dynamic viscosity (*second revision*)
[P : 29] : 2004/ ISO 6246 : 1995	Petroleum products — Gum content of light and middle distillate fuels — Jet evaporation method
[P : 31] : 2017	Smoke point (*first revision*)
[P : 34] : 1979	Determination of sulphur in petroleum products (lamp method)
[P : 42] : 2015/ ISO 6250 : 1997	Determination of the water reaction of aviation fuels (*third revision*)
[P : 97] : 2015/ ISO 6249 : 1999	Determination of thermal oxidation stability of gas turbine fuels — JFTOT method (*first revision*)
[P : 109] : 2004/ ISO 3012 : 1999	Petroleum products — Determination of thiol (mercaptan) sulphur in light and middle distillate fuels

IS No.	*Title*
[P : 113] : 1983	Determination of total acidity of aviation turbine fuels (ATF)
[P : 118] : 1985	Naphthalene hydrocarbons in aviation turbine fuels by UV spectrophotometry
[P : 142] : 1993	Determination of water separation characteristics of aviation turbine fuels by portable separometer
[P : 148] : 2002	Determination of electrical conductivity of aviation and distillate fuels containing static dssipator additive
1571 : 2018	Aviation turbine fuel, kerosene type, Jet A-1 —Specification (*tenth revision*)

3 REQUIREMENTS

3.1 General

The material shall be clear, bright and free from sediment, suspended matter and undissolved water at normal ambient fuel temperature.

3.2 Composition

3.2.1 Aviation turbine fuel (kerosene type, Jet A-1) containing synthesized hydrocarbons is a complex mixture of hydrocarbons that varies depending on crude oil and renewable feed source and manufacturing process. Consequently, it is impossible to define the exact composition of aviation turbine fuel (kerosene type, Jet A-1) containing synthesized hydrocarbons. This specification has therefore evolved primarily as a performance specification rather than a compositional specification. The fuel shall consist of synthetic blending components as mentioned in **3.2.2** and qualified additives as mentioned in **3.2.3** to **3.2.8**.

3.2.2 The permitted synthetic blending components and the ratio of blending with conventional Jet A-1 (IS 1571) shall be as follows:

Sl No. (1)	**Synthetic Component** (2)	**Limit (Percent by Volume, *Maximum*)** (3)	**Refer to ANNEX** (4)
i)	Fischer-Tropsch hydro-processed synthesized paraffinic kerosene (SPK)	50	A
ii)	Synthesized paraffinic kerosene from hydroprocessed ester and fatty acids	50	B
iii)	Synthesized iso-parafins from hydroprocessed fermented sugars	10	C
iv)	Synthesized kerosene with aromatics derived by alkylation of light aromatics from non-petroleum sources	50	D
v)	Alcohol-to-Jet synthetic paraffinic kerosene (ATJ-SPK)	50	E

3.2.3 *Antioxidants*

An approved antioxidant or mixture of antioxidants shall be added to a fuel (or component) that has been hydroprocessed (that is manufactured using a catalytic hydrogen process such as hydrotreating, hydrofining, hydrocracking, etc).This addition is to prevent peroxidation and gum formation, the point of anti-oxidant addition shall be before or during release from the manufacturing site. The total concentration of active material(s) in fuel or that proportion of the fuel blend that has been hydroprocessed shall not be less than 17.0 mg/l nor exceed 24.0 mg/l. Where a finished fuel comprises a blend of hydroprocessed and nonhydroprocessed components, the requirements for mandatory addition of antioxidant applies only to that portion of the blend which has been hydroprocessed. In such cases the proportion of the blend which has been hydroprocessed shall be reported.

NOTE — If fuel is certified before the addition of antioxidant, the certificate of quality should be annotated as: "Product meets the requirements of IS 1571, except for Antioxidant, which will be added prior to product leaving the manufacturing location."

For fuel (fuel component) which has not been hydroprocessed/synthesized, such addition is optional. However, the total concentration shall not exceed 24.0 mg/l and shall be reported on the certificate of quality.

Where a fuel, or a blend component of the fuel, has been hydro processed or severely hydro processed, the concentration of active material added to these portions of the blend shall be reported on the certificate of quality. If antioxidant has also been added to the nonhydroprocessed portion of the fuel the concentration of active material added to this portion should be reported on the separate line on the certificate of quality.

The following are some of the approved antioxidants:

Product	***Qualification Reference***
(a) 2,6-ditertiary-butyl-phenol	RDE/A/606
(b) 2,6 ditertiary-butyl-4-methyl-phenol	RDE/A/607

	Product	*Qualification Reference*
(c)	2,4-dimethyl-6-tertiary-butyl-phenol	RDE/A/608
(d)	75 percent minimum, 2,6 ditertiary-butyl-phenol; 25 percent minimum, tertiary and tritertiary-butyl-phenols;	RDE/A/609
(e)	55 percent minimum, 2,4-dimethyl-6-tertiary-butyl-phenol; 15 percent minimum, 4 methyl-2,6 ditertiary-butyl-phenol; remainder, 30 percent maximum, as a mixture of monomethyl and dimethyl-tertiary-butyl-phenols; and	RDE/A/610
(f)	72 percent minimum, 2,4-dimethyl-6-tertiary-butyl-phenol; 28 percent maximum, mixture of tertiary-butyl-methyl-phenols and tertiary-butyl-dimethyl-phenols	RDE/A/611

NOTE — The concentration of anti-oxidant added to the fuel should be reported as follows:

1 Report the total anti-oxidant addition as an equivalent concentration of active material in the proportion of the final batched fuel that comprises hydroprocessed, severely hydroprocessed, non- hydroprocessed and/or synthetic blend components on the certificate of quality.

2 Report the total active material concentration in the final batched fuel on the Refinery Certificate of Quality.

3 If the anti-oxidant is added during ship loading, the reporting requirements shall be the same as those in **1** and **2** above.

3.2.4 *Metal Deactivator Additive (MDA)*

An approved metal deactivator, N, N'-disalicylidene, 1,2-propanediamine, may be added in amount not exceeding 2.0 mg/l on initial batching of the fuel at the refinery and 5.7 mg/1 on cumulative addition when redoping the fuel to counteract the effects of metals known to be deleterious to thermal stability such as Cu, Cd, Co, Fe and Zn provided that the nature of the contamination is reported. Where metallic contamination is unproven, MDA may be used to recover thermal stability provided that JFTOT Test [in accordance with SI No. (vii) of Table 1] is determined before and after MDA addition and reported on the test certificate.

Product	*Qualification Reference*
N,N'-disalicylidene 1,2-propanediamine	RDE/A/650

3.2.5 *Static Dissipater Additive (SDA)*

3.2.5.1 Wherever necessary, a qualified SDA shall be added to the fuel to impart electrical conductivity in accordance with property Sl No. (x) of Table 1.

3.2.5.2 The concentrations in which SDA is to be added to the fuel are as follows:

a) The concentration of SDA to be used in newly manufactured, or on first doping of fuel is 3.0 mg/l maximum.

b) The cumulative concentration of SDA allowed when re-doping fuel to maintain conductivity is 5.0 mg/1 maximum.

NOTE — A suitable method for the determination of SDA concentration at the point of manufacture is IP 568 or ASTM D7524.

Product	*Manufacturer*	*Qualification Reference*
Stadis® 450	Innospec LLC	RDE/A/621
AvGuard SDA	Afton Chemicals	RDE/A/DSFA/001

3.2.6 *Lubricity Improver Additive (LIA)*

3.2.6.1 A qualified LIA may be added to the fuel to impart improved lubricity to the fuel.

NOTE — Further information on aviation turbine fuel lubricity is available at Annex H.

3.2.6.2 Because LIA exists in equilibrium with metal surfaces of fuel distribution systems as well as those of aircraft systems, correct delivery to aircraft can be assured only by equilibration of the supply system downstream of the LIA addition or by additive injection at the point of entry to the aircraft.

NOTE — Some of the qualified lubricity improving additives along with their concentration in which they are added to the fuel at the time of delivery to the purchaser are as follows:

Product	*Manufacturer*	*Qualification Reference*	*Minimum mg/l*	*Maximum mg/l*
Hitec 580	Afton Chemical Ltd.	RDE/A/661	15	23
Nalco 5403	Nalco Chemical Co.	RDE/A/664	12	23

3.2.7 *Fuel System Icing Inhibitor (FSII)*

3.2.7.1 A qualified FSII may be added to the fuel as agreed to between the purchasing authority and the supplier. Concentrations less than 0.02 percent by volume can be considered negligible and do not require agreement/notification. The assent to allow these small quantities of FSII without agreement/notification is to facilitate the changeover from fuels containing FSII where the additive may remain in the fuel system for a limited time. Under no circumstances is this background level allowed in fuel that is to be delivered through a filter monitor. This does not allow the continuous addition of FSII at these low concentrations.

3.2.7.2 Under no circumstances shall fuels containing FSII be delivered through a filter monitor.

3.2.7.3 The following material is qualified at the specified concentration mentioned below:

Product	*Concentration*	*Qualification Reference*
Di ethylene Glycol Mono methyl Ether (DGME)	Not less than 0.1 percent and not more 0.15 percent by volume	RDE/A/630

NOTES:

1 When LIA (*see* **3.2.5**) and FSII (*see* **3.2.6**) are to be used together, it may be found convenient to add the LIA in admixture with FSII. Whatever blending procedure is adopted, the supplier shall satisfy the purchaser that the correct concentration of LIA has been incorporated homogeneously. The supplier shall record the concentration of LIA and the information on the additives added shall be provided to the customer.

2 The material shall be added, where mandated, at a concentration of not less than 0.10 percent and not more than 0.15 percent by volume at the time of delivery to the purchaser. Suitable methods for determining the additive concentration are IP 424 and ASTM D 5006.

3.2.9 *Warning*

The addition of LIA to the fuel containing an SDA may further affect the electrical conductivity and MSEP of the fuel. Fuel containing SDA only or both of these types of additives shall comply with the appropriate requirements stated in Table 1 for electrical conductivity and MSEP unless agreed otherwise between the purchasing authority and the supplier.

3.2.10 *Leak Detection Additive*

Where necessary a leak detection additive may be added to the fuel to assist in detecting and locating leaks in ground based fuel storage, delivery and dispensing systems. It should be recognized that other leak detection techniques may have less environmental impact than Tracer A. The additive should only be used when other options have been considered.

NOTES:

1 The following material is qualified:

Product	*Manufacturer*	*Qualification Reference*
Tracer A (LDTA-A)	Tracer Research Corporation	RDE/A/640

2 The concentration of Tracer A shall not exceed 1.0 mg/kg

3.3 The material shall also conform to the requirements prescribed in Table 1 Part 1 and Part 2 in accordance with the limitations given in **3.2.2**. (for percent by volume of the synthetic blending component) when tested with test methods mentioned in col 4 of these Tables. The individual synthetic blending components shall further meet respective specifications as given in Annex A to E.

3.4 The fuel manufactured, certified and released against the requirements of Table 1 of this specification, meets the requirements of IS 1571, and shall be considered as specification IS 1571. Hence, duplicate testing is not necessary and the same data may be used for compliance of both these standards. Once fuel is released to this specification, the unique requirements of this specification are no longer applicable. Any subsequent recertification shall be done as per Table 1 of IS 1571.

NOTE — All test methods referred to in this standard include a precision statement. The interpretation of results based on test method/precision shall be used whenever applicable. In case of dispute the procedure described in ISO 4259 shall be used.

4 SAMPLING

4.1 Representative samples of material shall be drawn as prescribed in IS 1447 (Part 1).

NOTE — ASTM D 4057/D 4306 also exists for sampling.

4.2 Representative samples of each batch of the product shall be tested to prove homogeneity. On proving homogeneity, all characteristics given in the standard shall be tested on composite sample prepared by mixing representative samples, proportionately.

4.3 The lot shall be declared as conforming to the requirements of the standard, if all the test results on the composite sample meet relevant standard requirements.

5 PACKING AND MARKING

5.1 Packing

The material shall be packed in suitable containers as agreed to between the purchaser and the supplier subject to relevant rules and regulations in force in the country.

5.2 Marking

The material shall be supplied in accordance with the marking and delivery instructions given by the purchaser.

5.2.1 Each container shall be marked with the following information:

a) Name and grade of the material;
b) Indication of the source of manufacturer, initials or recognized trade-mark, if any;
c) Volume of the contents, in litres;
d) Year and month of manufacturing or packing; and
e) Any other statutory requirements.

5.2.2 Each container shall also be marked with the caution label 'Highly Flammable' together with the corresponding symbol for labelling dangerous goods [*see* IS 1260 (Part 1)].

5.2.3 *BIS Certification Marking*

The container may also be marked with the Standard Mark.

5.2.3.1 The use of Standard Mark is governed by the provisions of the *Bureau of Indian Standards Act*, 2016 and the Rules and Regulations made there under. The details of the conditions under which the licence for use of the Standard Mark may be granted to manufacturers or producers may be obtained from the Bureau of Indian Standards.

5.3 Handling and Storage

5.3.1 Once this fuel is re-designated as IS 1571 aviation turbine fuel, it needs to be handled in the same manner as that of the conventional refined IS 1571 aviation turbine fuel.

5.3.2 For handling and storage of the fuel, the instructions given in Aviation Quality Control and Assurance Manual approved by DGCA and guidelines issued by DGAQA shall be followed.

6 QUALITY ASSURANCE

6.1 The individual synthetic blending components shall meet respective specifications as given in Annex A to E. The test report of blending component shall contain:

a) Type of synthetic component;
b) Process approval reference from regulatory authorities;
c) Product originator details; and
d) Originator' certificate of quality.

This report shall be made available before undertaking blending.

6.2 The blended fuel shall be tested for all the requirements of Table 1 (Part 1 and Part 2) of this standard, at manufacturing point. The volume percent of the synthetic component shall be mentioned in the test report and report shall be made available.

6.3 The batch certification/release of blended fuel shall be as per this specification and shall have reference of test reports generated above. Duplicate testing is not necessary; the same data may be used for both this standard and IS 1571 in final certificate.

6.4 Any re-certification shall be done in accordance with IS 1571.

6.5 The additional requirements of Part 2 of this standard are not mandated if conventionally-derived jet fuel is mixed with the residue of a synthetic aviation turbine fuel confirming to this standard, in storage tank bottom from a previous batch of certified final blended product.

Table 1 Requirements of Aviation Turbine Fuels Containing Synthesized Hydrocarbons

(*Clause* 3.2, 3.3 and 3.4)

Part 1: Basic Requirements

Sl No.	**Characteristic**	**Requirement**		**Method of Test, Ref to [P :] of IS 1448/ASTM/IP/ISO**
(1)	(2)	(3)		(4)
i)	*Appearance:*			
	a) Visual appearance	Clear, bright and visually free from solid matter and undissolved water at ambient fuel temperature		Visual (*see* Annex D of IS 1571)
	b) Colour	Report1)		[P : 14]/ASTM D 156*/D 6045
	c) Particulate contamination, at point of manufacture, mg/l, *Max*	1.02)		ASTM D 5452*/IP 423
	d) Particulate, at point of manufacture, cumulative channel particle counts,	Channel counts	ISO Code3)	IP 564*, IP 565 or IP 577
	1) ≥ 4 µm(c)	Report	Report	
	2) ≥6 µm(c)	Report	Report	
	3) ≥14 µm(c)	Report	Report	
	4) ≥21 µm(c)	Report	Report	
	5) ≥25 µm(c)	Report	Report	
	6) ≥30 µm(c)	Report	Report	
ii)	*Composition:*			
	a) Total acidity, mg KOH/g, *Max*	0.015		[P : 113]*/IP 354/ASTM D3242
	b) Aromatics, v/v percent, *Max*	25.04)		[P : 23]*/IP 156/ASTM D 1319
	or			
	Total Aromatics, v/v percent, *Max*	26.5		IP 436/ASTM D 6379*
	c) Total sulfur, m/m percent, *Max*	0.305)		[P : 34]/ISO 8754/ASTM D 4294*
	d) Sulfur mercaptan, m/m percent, *Max*	0.0030 6)		[P : 109]*/IP 342/ASTM D 3227
	or			
	e) Doctor Test	Negative7)		[P : 19]*/IP 30/ASTM D 4952
	f) Refining components, at the point of manufacture 8)			
	1) Non Hydroprocessed Components, v/v percent	Report		
	2) Mildly Hydroprocessed Components, v/v percent	Report		
	3) Severely Hydroprocessed Components, v/v percent	Report		
	4) Synthetic Components,	Report		
	i) Name of the component			*see* Cl **3.2.2**
	ii) Component, v/v percent, Max			
iii)	*Volatility:*			
	a) Distillation:			[P : 18]*9)/IP 123/ASTM D 86
	1) Initial boiling point, °C	Report		
	2) 10 percent recovery °C, v/v, *Max*	205.0		
	3) 50 percent recovery °C, *v/v*	Report		
	4) 90 percent recovery °C, *v/v*	Report		
	5) Final boiling point,°C, *Max*	300.0		
	6) Residue, v/v percent, *Max*	1.5		
	7) Loss, v/v percent, *Max*	1.5		

Table 1 *(Concluded)*

Part 1: Basic Requirements

Sl No.	**Characteristic**	**Requirement**	**Method of Test, Ref to [P :] of IS 1448/ASTM/IP/ISO**
(1)	(2)	(3)	(4)
	b) Flash point (Abel), °C, *Min*	38.0	[P : 20]*/ISO 13736/IP 170
	c) Density at 15°C,kg/m^3	775.0 to 840.0	[P : 16]*/IP 160/ASTM D 4052
iv)	*Fluidity*		
	a) Freezing point, °C, *Max*	-47	[P : 11]*/IP 16/ASTM D 2386/ D7153
	b) Kinematic viscosity at minus 20°C, mm^2/s, *Max*	8.000	[P : 25/Sec 1]*/IP 71/ASTM D 445
v)	*Combustion:*		
	a) Specific energy[10] MJ/kg, *Min*	42.80	[P : 6]/ASTM D 3338*
	b) Smoke point, mm, *Min* or	25.0	[P : 31]/IP 598*[11]/ASTM D 1322
	1) Smoke point, mm, *Min* and	18.0	[P : 31]/IP 598*[11]/ASTM D 1322
	2) Naphthalenes, v/v percent*, Max*	3.00	[P : 118]*/ASTM D 1840
vi)	*Corrosion:*		
	a) Copper strip corrosion for 2 h at 100°C	Not worse than No. 1	[P : 15]*/IP 154/ASTM D 130
	b) Silver strip corrosion[12] classification, for 4 h at 50ºC, *Max*	“0” at Refinery “1” at Delivery Point	Annex F
vii)	*Thermal Stability, JFTOT at Control Temperature of 260°C*		
	a) Filter pressure differential, mm Hg, *Max*	25	[P : 97]/IP 323/ASTM D 3241*
	b) One of the following requirement to be met a)		
	i) Tube rating, visual (VTR)	Less than 3, No ‘Peacock’ (P) or ‘Abnormal’ (A)	Note 13 and 14
	or		
	ii) ITR or ETR, average over area of 2.5 mm^2, nm, *Max*	85	
viii)	*Contaminants:*		
	Existent gum, mg/100 ml, *Max*	7	[P : 29] [15]*/IP 540/ASTM D 381
ix)	*Water Separation Characteristics:*		
	a) Water reaction: Interface rating[16], *Max*	1b	[P : 42]
	b) Micro-separometer rating[18] at the point of manufacture:		[P : 142]*[17]/ASTM D 3948
	1) MSEP without SDA, *Min*	85	
	2) MSEP with SDA, *Min*	70	
x)	*Conductivity:*		
	Electrical conductivity, pS/m [19]	50 - 600	[P : 148]*/ISO 6297/IP 274/ ASTM D2624
xi)	*Lubricity:*		
	Wear scar diameter, mm, *Max*	0.85[20]	ASTM D 5001
xii)	Identified Incidental Materials Fatty Acid Methyl Ester, mg/kg, *Max*	50[21]	IP 585* or IP 590 (*see* Note 22)

* Denotes referee method in the above table

NOTES:

1 The requirement to report Saybolt Colour shall apply at point of manufacture, thus enabling a colour change in distribution to be quantified. Where the colour of the fuel precludes the use of the Saybolt Colour test method, then the visual colour shall be reported. Unusual or atypical colours should also be noted. For further information on the significance of colour (*see* Annex C of IS 1571).

2 Refer to the information on particulate contamination in Annex D of IS 1571.

3 Both number of particles and number of particles as a scale number as defined under Table 1 of ISO 4406 shall be reported.

4 Defence requirements to be met at 22 percent by v/v, maximum.

5 Defence requirements to be met at 0.25 percent m/m total Sulphur, maximum.

6 Defence requirements to be met at 0.002 percent by m/m, maximum.

7 The alternative requirement e) is a secondary requirement to d). In the event of a conflict between Sulphur Mercaptan (d) and Doctor Test (e) results, requirement d) shall prevail.

8 Each Refinery component used in the make-up of the batch shall be reported on the Refinery Certificate of Quality as a percentage by volume of the total fuel in the batch. Mildly hydro processed components are defined as those petroleum derived hydrocarbons that have been subjected to a hydrogen partial pressure of less than 7000 kPa (70 bar or 1015 psi) during manufacture. Severely hydroprocessed components are defined as those petroleum derived hydrocarbons that have been subjected to a hydrogen partial pressure of greater than 7000 kPa (70 bar or 1015 psi) during manufacture. The total of non-hydroprocessed plus mildly hydroprocessed plus severely hydroprocessed plus synthetic components shall be equal to 100 percent v/v.

9 In method [P : 18], all fuels certified to this specification shall be classed as group 4 with a condenser bath temperature of 0 to 4°C.

10 Specific energy by one of the calculation methods listed under Annex G will be acceptable. Where a measurement of specific energy is deemed necessary, the method to be used shall be agreed between the purchaser and supplier.

11 The automated method in IP598 is the referee method.

12 It is only a Defence requirement. Annex F to be followed.

13 The annexes referred to in Table 1 and this note correspond to those in IP323. If the technically equivalent ASTM D3241 test method is used, the same protocol shall be followed using the appropriate annex that corresponds to the visual (VTR), interferometric (ITR) or ellipsometric (ETR) method. Tube deposit ratings shall be measured by IP323 Annex C ITR or Annex D ETR, when available. If the Annex C ITR device reports “N/A” for a tube’s volume measurement, the test shall be a failure and the value reported as >85 nm. Visual rating of the heater tube shall be by the method in IP323. Annex B is not required when Annex C ITR or Annex D ETR deposit thickness measurements are reported. In case of dispute between results from visual and metrological methods, the metrological method shall be considered the referee.

14 Examination of the heater tube to determine the Visual Tube Rating using the Visual Tube Rater or deposit thickness by ETR or ITR shall be carried out within 120 minutes of completion of the test.

15 Air may be used instead of steam as the evaporating medium so long as the temperatures remain as specified in [P : 29] of IS 1448, Table 1-Test Conditions for Aviation Turbine Fuel for Steam Jet Apparatus. When carrying out this procedure, air flow calibration should be adjusted to give an air flow of 600 ml/s at ambient conditions. The beaker should still undergo the same pre-heating as in steam jet procedure.

16 Whenever MSEP is reported this test need not be carried out.

17 If the sample contains sediment or insoluble matter, it shall be allowed to stand and clear fuel decanted for testing. The sample shall not be filtered.

18 These MSEP requirements apply only at the point of manufacture. No precision data are available for fuels containing SDA. If MSEP testing is carried out during downstream distribution no specification limits apply and results arc not to be used as the sole reason for rejection of a fuel. Where SDA is added at point of manufacture the MSEP limit of 70 shall apply. No precision data are available for fuels containing SDA; if MSEP testing is carried out during downstream distribution no specification limits apply and the results are not to be used as the sole reason for rejection of a fuel. A protocol giving guidelines on possible actions to be taken following failed MSEP testing can be found in the Joint Inspection Group’s Bulletin Number 65, MSEP Protocol at ‘www.jigonline.com’ under ‘fuel quality’. Where SDA is added downstream of point of manufacture, it is acknowledged that MSEP results may be less than 70.

19 The conductivity limits are mandatory for product to meet this specification. However it is acknowledged that in some manufacturing and distribution systems it is more practical to inject SDA further downstream. In such cases the Certificate of Quality for the batch should be annotated thus: “Product meets requirements of IS xxxx except for electrical conductivity”. The Specification Authority is also aware of situations where conductivity can decrease rapidly and the fuel can fail to respond to additional dosing of Stadis 450 (refer Annex H of DefStan 91 -091 issue 9 for more information).

20 Defence requirements to be met at 0.65 mm, *Max*. Irrespective of method of production of ATF, that is, Hydrotreated, sweetening process or mixed, lubricity in terms of WSD shall be reported in the Test Reports. If ‘as is’ WSD of ATF is greater than 0.65 mm at the point of production at the refinery, the desired WSD shall be obtained at the refineries after doping with the approved lubricity additive as mentioned in **3.2.5** and the quantity thus required to obtain WSD < 0.65 mm shall be annotated in the batch test reports. If the quantity of LIA required for any of the batches of ATF at the refineries is found to be more than the stipulated maximum of the respective LIA as given in **3.2.5.2**, then such batches of ATF shall not be supplied by the refineries nor utilized by the defence. For the batches of ATF of WSD > 0.65 mm, doping of optimized quantity of respective LIA stipulated by CEMILAC shall be mandatorily undertaken just before ATF is inducted into the aircraft. All activities of compliance in respect of doping and maintenance of relevant records for traceability point of view shall be vested solely by the supplier of ATF namely, Aviation Filling Station (AFS).

21 *See* E-5 of Annex E and F-4 of Annex F of IS 1571, for additional information on identified incidental materials and FAME. On an emergency basis, up to 100 mg/kg FAME is permitted in blended jet fuel when authorized by the airframe and engine manufacturers and managed in compliance with airframe and engine manufacturer requirements. An emergency basis can be defined as an unexpected and unforeseen situation that requires prompt action. For example where FAME contamination has been introduced into part of an airport distribution system where it cannot be quickly segregated or isolated for remediation without halting airport refuelling operations. All such instances should be raised through the procurement Authority, Duty Holder or Aircraft Operator.

22 Post manufacture a risk assessment shall be undertaken to quantify the potential risk of FAME carryover in all supply chains. Where such assessments indicate that there could be a potential risk in jet fuel supplies, additional quality assurance procedures shall be introduced to increase control in order to mitigate the risk. Where the risk of FAME carryover exists and it is not possible to control with additional quality assurance procedures, testing shall be instigated. Further guidance on how to verify compliance with this requirement is contained in Annex F.

The RCQ/COQ shall state. "Not measured, Risk assessed in accordance with JIG bulletin 106" against the FAME result in the specification requirement.

23 All test methods referred to in this standard include a precision statement. The interpretation of results based on test method/precision shall be used whenever applicable. In case of dispute the procedure described in ISO 4259 shall be used.

Part 2-Extended Requirements[24] for Aviation Turbine Fuels Containing Synthesized Hydrocarbons

Sl No.	Characteristic	Extended Requirement	Method of Test[25)] Ref to [P :] of IS 1448/IP/ASTM D
(1)	(2)	(3)	(4)
i)	*Composition*:		
	Aromatics, v/v percent, *Min*[26),27)]	8	[P : 23]*/IP 156/ASTM D 1319
	(*or*)		
	Total Aromatics, v/v percent, *Min*[26),27)]	8.4	IP 436/ASTM D 6379*
ii)	*Distillation*:		[P : 18]*/D2887/IP 406[28)]/D86[29)]/ IP 123[29)]
	a) T50- T10, °C, *Min*[27),30)]	15	
	b) T90-T10, °C, *Min*[27),30)]	40	
iii)	Fluidity[31)]		
	Viscosity –40 °C, mm^2/s, *Max*	12	D445[32)]/IP 71, Section 1[32)]/D7945

* Denotes referee method in the above table

NOTES:

24 The additional requirements of Part 2 of Table 1 apply only for each batch of fuel intentionally containing a synthetic Blending component. The additional requirements of Part 2 of Table 1 are not mandated if conventionally-derived jet fuel is mixed with the residue of a semi-synthetic aviation turbine fuel in refinery equipment from a previous batch of Certified final blended product, for example in a tank heel.

25 For additional test methods refer Annex "G."

26 Minimum aromatics contents are based on current experience with the approved synthetic fuels and those levels were established from what is typical for refined jet fuel. Research is ongoing on the actual need for aromatics.

27 The minimum aromatics and distillation slope criteria only apply to aviation turbine fuels containing synthesized hydrocarbons produced to this specification and are not applicable to conventional aviation turbine fuels produced to Specification IS 1571. Some batches of aviation turbine fuels produced to Specification IS1571 may not meet the minimum aromatics and distillation slope criteria specified in Table 1 (Part 2) of this specification.

28. Distillation property criteria are specified in D86 or IP 123 scale units. D2887/IP 406 results shall be converted to estimated D86 or IP 123 results by application of the correlation in Appendix X4 of D2887 or Annex G of IP 406 for comparison with the specified property criteria. Distillation residue and loss limits provide control of the distillation process during the D86 and IP 123 test methods and do not apply to D2887/IP 406. Distillation residue and loss shall be reported as "not applicable" (N/A) when reporting D2887/IP 406 results.

29 D86 or IP 123 distillation of jet fuel is run at Group 4 conditions, except Group 3 condenser temperature is used.

30 These distillation slope limits are based on current experience with the approved synthetic fuels and these values were established from what is typical for refined jet fuel. Research is ongoing on the actual requirements for distillation slope.

31 The fluidity requirement applies only to jet fuel containing HEFA-SPK specified in Annex B and synthesized iso-paraffins specified in Annex C. It also applies for ATJ-SPK specified in Annex E blended above 30 percent. It does not apply to jet fuel containing Annex A or Annex D synthesized components.

32 D445 or IP 71, Section 1 allows measuring the viscosity at –40 °C, however the precision values were determined down to –20 °C.

ANNEX A

SYNTHESIZED HYDROCARBONS BLENDSTOCKS

(*Clause* 3.2.2)

FISCHER-TROPSCH HYDROPROCESSED SYNTHESIZED PARAFFINIC KEROSENE (FT-SPK)

A-1 SCOPE

A-1.1 This Annex defines hydroprocessed synthesized paraffinic kerosene (SPK) for use as a synthetic blending component in aviation turbine fuels for use in aircraft gas turbine engines designed to operate on such fuel. The specifications in Table A-1 and A-2 are to be used for contractual exchange of synthetic blending components.

A-1.2 The synthetic blending components defined in this Annex cannot be used for aviation turbine engines unless blended with conventional fuel or conventional blending components in accordance with the limitations as described in **3.2.2**.

A-2 COMPOSITION

FT-SPK synthetic blending components shall be comprised of hydroprocessed synthesized paraffinic kerosene wholly derived from paraffins and olefins derived from synthesis gas via the Fischer-Tropsch (FT) process using Iron or Cobalt catalyst. Subsequently the product shall be processed by hydrotreating, hydrocracking, or hydroisomerization and is expected to include, but not be limited to, a combination of other conventional refinery processes such as polymerization, isomerization, and fractionation.

A-3 BATCH REQUIREMENTS

Each batch of synthetic blending component shall conform to the requirements given in Table A-1.

A-4 OTHER DETAILED REQUIREMENTS

The hydroprocessed SPK blend component shall meet the requirements of Table A-2. It is not essential to analyse each batch of hydroprocessed SPK for compliance with Table A-2, once it is demonstrated that the manufacturing process is adequately controlled to support the expectation that these requirements are always met. However, in case of significant changes in production operations, recertification is essential to ensure that these requirements continue to be met.

Table A-1 Detailed Batch Requirements; Fischer-Tropsch Hydroprocessed SPK[1)]

Sl No.	Characteristic	Requirement of FT-SPK	Method of Test[2)] Ref to [P :] of IS 1448/IP/ASTM D
(1)	(2)	(3)	(4)
i)	*Composition:*		
	a) Acidity, total mg KOH/g, *Max*	0.015	[P :113][2)]/D3242/IP 354
ii)	*Volatility:*		
	a) Distillation-both of the following requirements shall be met:		[P : 18][2),3)]/D86[3)]/IP 123[3)]/D 7345
	1) Physical Distillation		
	Distillation temperature, °C:		
	i) 10 percent recovered, temperature (T10) *Max*	205	
	ii) 50 percent recovered, temperature (T50)	report	
	iii) 90 percent recovered, temperature (T90)	report	
	iv) Final boiling point, temperature *Max*	300	
	v) T90-T10, °C *Min*	22	
	vi) Distillation residue, percent v/v, *Max*	1.5	
	vii) Distillation loss, percent v/v, *Max*	1.5	

Table A-1 *(Concluded)*

Sl No.	Characteristic	Requirement of FT-SPK	Method of Test[2] Ref to [P :] of IS 1448/IP/ASTM D
(1)	(2)	(3)	(4)
	2) Simulated Distillation		D2887/IP 406
	Distillation temperature, °C:		
	i) 10 percent recovered, temperature (T10)	report	
	ii) 50 percent recovered, temperature (T50)	report	
	iii) 90 percent recovered, temperature (T90)	report	
	iv) Final boiling point, temperature	report	
iii)	*Flash point, °C(Abel), Min*	38[4]	[P : 20][2]/ISO 13736/D3828/IP 170/IP 523
iv)	*Density at 15 °C, kg/m*^{3}	730 to 770	[P : 16][2]/D1298/IP 160/D4052/IP 365
v)	*Freezing point, °C, Max*	- 40	[P : 11][2]/D5972/IP 435, D7153/IP 529/ D7154/IP 528/D2386/IP 16
vi)	*Thermal Stability (2.5 h at control temperature):*		
	a) Temperature, °C, *Min*	325 [5]	[P : 97]/D3241[2,6]/IP 323[6]
	b) Filter pressure drop, mm Hg, *Max*	25	
	c) Tube rating: One of the following requirements shall be met:[7]		
	1) VTR, VTR Color Code	<3, No peacock or abnormal color deposits	
	or		
	(ITR or ETR, average over area of 2.5 mm^2, nm, *Max*	85	
vii)	*Additives:*		
	a) Antioxidants, mg/L [8]	17-24	

NOTES:

1 Test results shall not exceed the maximum or be less than the minimum values specified in Table 1, Tables A-1 and A-2.

2 Denotes referee method in case of dispute. For additional alternate test methods refer Annex G.

3 D86 or IP 123 distillation of jet fuel is run at Group 4 conditions, except Group 3 condenser temperature is used.

4 A higher or lower minimum flash point specification may be agreed upon between purchaser and supplier. When the agreed flash point is less than 38 °C then the product shall not be known as SPK or as kerosene, but may be used as an Annex A blending component.

5 Control temperature of 325 °C is specified to provide a recurring, batch-by-batch verification of process stability and compositional consistency.

6 D3241/IP 323 Thermal Stability is a critical aviation fuel test, the results of which are used to assess the suitability of jet fuel for aviation operational safety and regulatory compliance. The integrity of D3241/IP 323 testing requires that heater tubes (test coupons) meet the requirements of D3241 Table 2 and give equivalent D3241 results to the heater tubes supplied by the original equipment manufacturer (OEM).

7 Tube deposit ratings shall be measured by D3241 Annex ITR or Annex ETR, when available. If the Annex A2 ITR device reports "N/A" for a tube's volume measurement, the test shall be a failure and the value reported as >85 nm. Visual rating of the heater tube by the method in D3241 Annex A1 is not required when Annex A2 ITR or Annex A3 ETR deposit thickness measurements are reported. In case of dispute between results from visual and metrological methods, the referee shall be considered the Annex A3 ETR method if available, otherwise Annex A2 ITR.

8 Antioxidant shall be added to the bulk product prior to movements or operations that will significantly expose the product to air and in such a way as to ensure adequate mixing. This shall be done as soon as practicable after hydroprocessing or fractionation to prevent peroxidation and gum formation after manufacture. In-line injection and tank blenders are considered acceptable methods for ensuring adequate mixing.

Table A-2 Other Detailed Requirements; Fischer-Tropsch Hydroprocessed SPK

(*Clause* A-6)

Sl No.	Characteristic	Requirement of FT-SPK	Method of Test[1)] Ref to [P :] of IS 1448/IP/ASTM D
(1)	(2)	(3)	(4)
i)	*Hydrocarbon Composition:*		D2425
	a) Cycloparaffins, m/m percent, *Max*	15[2)]	
	b) Aromatics, m/m percent, *Max*	0.5	
	c) Paraffins, m/m percent	report	
	d) Carbon and Hydrogen, m/m percent, *Min*	99.5	D5291
ii)	*Non-hydrocarbon Composition:*		
	a) Nitrogen, mg/kg, *Max*	2	D4629 or IP 379
	b) Water, mg/kg, *Max*	75	D6304 or IP 438
	c) Sulfur, mg/kg, *Max*	15	D5453 or D2622
	d) Metals (Al, Ca, Co, Cr, Cu, Fe, K, Mg, Mn, Mo, Na, Ni, P, Pb, Pd, Pt, Sn, Sr, Ti, V, Zn), mg/kg, *Max*	0.1 per metal	UOP 389/ASTM D 7111
	e) Halogens, mg/Kg, *Max*	1	D7359

NOTES:

1 For additional alternate test methods refer Annex G.

2 Maximum cycloparaffin composition is based on current experience with the approved synthetic fuels and is within the range of what is typical for refined jet fuel.

ANNEX B

SYNTHESIZED PARAFFINIC KEROSENE FROM HYDROPROCESSED ESTER AND FATTY ACIDS

B-1 SCOPE

B-1.1 This Annex defines synthesized paraffinic kerosene produced from hydroprocessed esters and fatty acids for use as a synthetic blending component in aviation turbine fuels for use in aircraft gas turbine engines designed to operate on such fuel. The specifications in Table B-1 and B-2 are to be used for contractual exchange of synthetic blending components.

B-1.2 The synthetic blending components defined in this Annex cannot be used for aviation turbine engines unless blended with conventional fuel or conventional blending components in accordance with the limitations with up to 50 percent by volume of the synthetic blending component as specified in **3.2.2**.

B-2 TERMINOLOGY

B-2.1 Hydroprocessed Esters and Fatty Acids (HEFAs), *n* — Mono-, di-, and triglycerides, free fatty acids and fatty acid esters (for example, fatty acid methyl esters) that have been hydroprocessed to remove essentially all oxygen.

B-3 COMPOSITION

Synthetic blend components shall comprise of hydroprocessed synthesized paraffinic kerosene wholly derived from hydrogenation and deoxygenation of fatty acid esters and free fatty acids. Processing shall include hydrocracking, or hydroisomerization, or isomerization, or fractionation, or a combination thereof, and may include other conventional refinery processes.[1)]

NOTE — The following report provides a more detailed description of the composition and performance of hydroprocessed ester and fatty acid blending components that evolved from the evaluation of representative samples of these blending components.

i) For Supporting data, “Evaluation of Bio-Derived Synthetic Paraffinic Kerosene (Bio-SPKs),” prepared by The Boeing Company/UOP/United States Air Force Research Laboratory (AFRL), Version 5.0, May 2010, Research Report RR:D02-1739, ASTM International may be approached to.

ii) Supporting data provided to CEMILAC/DGAQA/BIS/DGCA for the CSIR-IIP’s process for the hydroprocessing of Esters and Fatty Acids for the production of hydrocarbons and their product performance characteristics data provided by CSIR IIP are available with BIS. (Research Report: ICRD08054 and HA/CCD/2018/Bio-ATF-157).

B-4 BATCH REQUIREMENTS

Each batch of HEFA SPK blending component shall conform to the requirements prescribed in Table B-1.

B-5 OTHER DETAILED REQUIREMENTS

The HEFA SPK blend component shall meet the requirements of Table B-2. These requirements are intended to verify the control of processes during the initial production scale-up of these synthetic blend components. However, Table B-2 requirements are further required only when new production facilities or schemes are established, or when significant changes to existing production operations are implemented, such as the introduction of a new feedstock material.

NOTE — It is the ultimate objective of this specification authority to transition these batch requirements to a management of change requirement once sufficient production experience is gained.

Table B-1 Batch Requirements; SPK from Hydroprocessed Esters and Fatty Acids[1]

(*Clause* B-4)

Sl No.	Characteristic	Requirement of HEFA-SPK	Method of Test[2] Ref to [P :] of IS 1448/IP/ASTM D
(1)	(2)	(3)	(4)
i)	*Composition:*		[P : 113][2]/D3242/IP 354
	a) Acidity, total mg KOH/g, *Max*	0.015	
ii)	*Volatility:*		
	a) Distillation-both of the following requirements shall be met:		[P : 18][2),3)]/D86[3]/IP 123[3]/D7345
	1) Physical Distillation		
	Distillation temperature, °C:		
	i) 10 percent recovered, temperature (T10) *Max*	205	
	ii) 50 percent recovered, temperature (T50)	report	
	iii) 90 percent recovered, temperature (T90)	report	
	iv) Final boiling point, temperature *Max*	300	
	v) T90-T10, °C *Min*	22	
	vi) Distillation residue, v/v percent *Max*	1.5	
	vii) Distillation loss, v/v percent *Max*	1.5	
	2) Simulated Distillation		D2887
	Distillation temperature, °C:		
	i) 10 percent recovered, temperature (T10)	report	
	ii) 50 percent recovered, temperature (T50)	report	
	iii) 90 percent recovered, temperature (T90)	report	
	iv) Final boiling point, temperature		
iii)	Flash point, °C, *Min*	38 [4]	[P : 20][2]/ISO 13736/D3828/IP 170/ IP 523
iv)	Density at 15 °C, kg/m^3	730 to 772[5]	[P : 16[2]/D1298/IP 160/D4052/ IP 365
v)	Freezing point, °C, *Max*	-40	[P : 11][2]/D5972/IP 435/D7153/ IP529/D7154/IP528/D2386/IP 16
vi)	Existent gum, mg/100 ml, *Max*	7	[P : 29][2]/D381/IP 540
vii)	FAME, ppm, Max	<5	[P : 585][2]/IP 590
viii)	Thermal Stability (2.5 h at control temperature)		
	a) Temperature. °C, *Min*	325[6]	[P : 97]/D3241[2),7)]/IP 323[7]
	b) Filter pressure drop, mm Hg, *Max*	25	
	c) Tube rating: One of the following requirements shall be met:[8]	< 3	
	1) Tube rating, visual (VTR)	Less Than 3, No peacock or abnormal color deposits	
	or		
	2) ITR or ETR, average over area of 2.5 mm^2, nm, *Max*	85	
ix)	Additives		
	Antioxidants, mg/l[9]	17-24	

NOTES:

1 Test results shall not exceed the maximum or be less than the minimum values specified in Table 1, Tables B-1 and B-2.

2 Denotes referee method in case of dispute. For additional alternate test methods, refer Annex G.

3 P18, D86 or IP 123 distillation of jet fuel is run at Group 4 conditions, except Group 3 condenser temperature is used.

4 A higher or lower minimum flash point specification may be agreed upon between purchaser and supplier. When the agreed flash point is less than 38 °C then the product shall not be known as SPK or as kerosene, but may be used as an Annex B blending component.

5 For Supporting data related to the maximum density limit ASTM International may be approached.

6 Control temperature of 325 °C is specified to provide a recurring, batch-by-batch verification of process stability and compositional consistency.

7 D3241/IP 323 Thermal Stability is a critical aviation fuel test, the results of which are used to assess the suitability of jet fuel for aviation operational safety and regulatory compliance.

8 Tube deposit ratings shall be measured by D3241 Annex A2 ITR or Annex A3 ETR, when available. If the Annex A2 ITR device reports "N/A" for a tube's volume measurement, the test shall be a failure and the value reported as >85 nm. Visual rating of the heater tube by the method in D3241 Annex A1 is not required when Annex A2 ITR or Annex A3 ETR deposit thickness measurements are reported. In case of dispute between results from visual and metrological methods, the referee shall be considered the Annex A3 ETR method if available, otherwise Annex A2 ITR.

9 Antioxidant shall be added to the bulk product prior to movements or operations that will significantly expose the product to air and in such a way as to ensure adequate mixing. This shall be done as soon as practicable after hydroprocessing or fractionation to prevent peroxidation and gum formation after manufacture. In-line injection and tank blenders are considered acceptable methods for ensuring adequate mixing.

Table B-2 Other Detailed Requirements; SPK from Hydroprocessed Esters and Fatty Acids

(*Clause* B-5)

Sl No.	Characteristic	Requirement of HEPA-SPK	Method of Test[1)] Ref to [P :] of IS 1448/IP/ASTM D
(1)	(2)	(3)	(4)
i)	*Hydrocarbon Composition:*		D2425
	a) Cycloparaffins, m/m percent, *Max*	20[2)]	
	b) Aromatics, m/m percent, *Max*	15[2)]	
	c) Paraffins, m/m percent	report	
	d) Carbon and Hydrogen, m/m percent *Min*	99.5	D5291
ii)	*Non- Hydrocarbon Composition:*		
	a) Nitrogen, mg/kg, *Max*	2	D4629/IP 379
	b) Water, mg/kg, *Max*	75	D6304/IP 438
	c) Sulfur, mg/kg, *Max*	50[2)]	D2622/D4294/D5453
	d) Metals (Al, Ca, Co, Cr, Cu, Fe, K, Mg, Mn, Mo, Na, Ni, P, Pb, Pd, Pt, Sn, Sr, Ti, V, Zn), mg/kg, *Max*	0.1 per metal	UOP 389/D 7111
	e) Halogens, mg/Kg, *Max*	1	D7359

NOTES:

1 For additional alternate test methods, refer Annex G.

2 Specification limits of cycloparaffins, aromatics and sulfur composition are based on indigenously developed process (Ref: IIP document HA/CCD/2018/Bio-ATF-157) and are within the range of what is typical for refined Jet Fuel. As these limits are finalized based on the current limited experience and are different from Def Stan 91-091 and ASTM D7566, same needs to be agreed between supplier, aircraft manufacturer, regulatory agencies and end user.

ANNEX C

SYNTHESIZED ISO-PARAFINS FROM HYDROPROCESSED FERMENTED SUGARS

C-1 SCOPE

C-1.1 This Annex defines synthesized iso-paraffins (SIP) produced from hydroprocessed fermented sugars for use as a synthetic blending component in aviation turbine fuels for use in aircraft gas turbine engines designed to operate on such fuel. The specifications in Table C-1 and C-2 are to be used for contractual exchange of synthetic blending components.

C-1.2 The synthetic blending components defined in this Annex cannot be for aviation turbine engines unless blended with conventional fuel or conventional blending components in accordance with the limitations as described in **3.2.2**.

C-2 TERMINOLOGY

C-2.1 Farnesane, n—iso-Paraffin with Chemical Formula : $C_{15}H_{32}$, chemical name: 2,6,10-trimethyldodecane (CAS Registry Number: 3891-98-3).

C-2.2 Farnesene, n—Branched Alkene with Chemical Formula : $C_{15}H_{24}$ consisting of isomers and containing at least (6E)-7,11-dimethyl-3-methylene-1,6,10-dodecatriene (CAS Registry Number: 18794-84-8) or (E,E)-3,7,11-trimethyl-1,3, 6,10-dodecatetraene (CAS Registry Number: 502-61-4).

C-2.3 Hexahydrofarnesol, n—Alkyl Alcohol with Chemical Formula : $C_{15}H_{32}O$, chemical name: 3,7,11-trimethyl-1- dodecanol (CAS Registry Number: 6750-34-1).

C-2.4 Synthesized Iso-Paraffins from Hydroprocessed Fermented Sugars, *n* — Farnesane that is produced by hydroprocessing and fractionation of farnesene derived from fermentation of sugars.

C-3 COMPOSITION

Synthetic blend components shall be comprised of hydroprocessed synthesized iso-paraffins wholly derived from farnesene produced from fermentable sugars. Subsequent processing of farnesene into iso-paraffins shall include a combination of hydroprocessing and fractionation operations, and may include other conventional refinery processes. In particular, hydroprocessing operations consist of reacting hydrogen with farnesene feedstock and fractionation operations consist of gas/liquid separation and isolation of synthesized iso-paraffins. Fractionation typically includes a distillation step.

C-4 BATCH REQUIREMENTS

Each batch of SIP blending component shall conform to the requirements prescribed in Table C-1.

C-5 OTHER DETAILED REQUIREMENTS

The SIP blend component shall meet the requirements of Table C-2. These requirements are intended to verify the control of processes during the initial production scale-up of these synthetic blend components. However, Table C-2 requirements are further required only when new production facilities or schemes are established, or when significant changes to existing production operations are implemented, such as the introduction of a new feedstock material.

NOTE — It is the ultimate objective of this specification authority to transition these batch requirements to a management of change requirement once sufficient production experience is gained.

Table C-1 Detailed Batch Requirements; SIP from Hydroprocessed Fermented Sugars[1]

(*Clause* B-4)

Sl No.	Characteristic	Requirement of SIP	Method of Test[2] Ref to [P :] of IS 1448/IP/ASTM D
(1)	(2)	(3)	(4)
i)	*Composition:*		
	a) Acidity, total mg KOH/g, *Max*	0.015	[P : 113][2]/IP 354/ASTM D3242
ii)	*Volatility:*		
	a) Distillation-both of the following requirements shall be met:		[P : 18][3,2]/D 86[3]/IP 123[3]/D 7345
	1) Physical Distillation		
	Distillation temperature, °C:		
	i) 10 percent recovered, temperature (T10) *Max*	250	
	ii) 50 percent recovered, temperature (T50)	Report	
	iii) 90 percent recovered, temperature (T90)	Report	
	iv) Final boiling point, temperature *Max*	255	
	v) T90-T10, °C *Min*	5	
	vi) Distillation residue, v/v percent, *Max*	1.5	
	vii) Distillation loss, v/v percent, *Max*	1.5	
iii)	*Flash point, °C Min*	100	[P : 21][2]/ISO 2719/D 93/IP 34/IP 523 /D3828
iv)	*Density at 15 °C,* kg/m^3	765 to 780	[P : 16][2]/D 1298/IP 160/D 4052/IP 365
v)	*Freezing point, °C, Max*	-60	[P : 11][2]/D5972/IP 435/D7153/IP 529 /D7154/IP 528/D2386/IP 16
vi)	*Contaminants :*		
	a) Existent gum, mg/100 ml, *Max*	7	[P : 29][2]/D 381/IP 540
	b) Microseparator, Rating (Without electrical conductivity additive), *Min*	85	[P : 142][2]/ASTM D 3948
vi)	*Thermal Stability (2.5 h at control temperature):*		
	a) Temperature, °C, *Min*	355 [4]	[P : 97]/D 3241[2,5]/IP 323[5]
	b) Filter pressure drop, mm Hg, *Max*	25	
	c) Tube rating: One of the following requirements shall be met:[6]		
	1) Tube rating, visual(VTR)	<3, No peacock or abnormal color deposits	
	or		
	2) ITR or ETR, average over area of 2.5 mm^2, nm, *Max*	85	
vii)	*Combustion:*		
	a) Net Heat of Combustion, MJ/Kg, *Min*	43.5	D 3338/D 4809[2]
viii)	*Additives:*		
	a) Antioxidants, mg/L [7]	17-24	

NOTES:

1 Test results shall not exceed the maximum or be less than the minimum values specified in Table 1, Table C-1 and C-2.

2 Denotes referee method in case of dispute. For additional alternate test methods refer Annex G.

3 [P : 18], D86 or IP 123 distillation of jet fuel is run at Group 4 conditions, except Group 3 condenser temperature is used.

4 Control temperature of 355 °C is specified to provide a recurring, batch-by-batch verification of process stability and compositional consistency.

5 D3241/IP 323 Thermal Stability is a critical aviation fuel test, the results of which are used to assess the suitability of jet fuel for aviation operational safety and regulatory compliance. The integrity of D3241/IP 323 testing requires that heater tubes (test coupons) meet the requirements of D3241 Table 2 and give equivalent D3241 results to the heater tubes supplied by the original equipment manufacturer (OEM).

6 Tube deposit ratings shall be measured by D3241 Annex ITR or Annex ETR, when available. If the Annex ITR device reports "N/A" for a tube's volume measurement, the test shall be a failure and the value reported as >85 nm. Visual rating of the heater tube by the method in D3241 Annex A1 is not required when Annex A2 ITR or Annex A3 ETR deposit thickness measurements are reported. In case of dispute between results from visual and metrological methods, the referee shall be considered the Annex A3 ETR method if available, otherwise Annex A2 ITR.

7 Antioxidant shall be added to the bulk product prior to movements or operations that will significantly expose the product to air and in such a way as to ensure adequate mixing. This shall be done as soon as practicable after hydroprocessing or fractionation to prevent peroxidation and gum formation after manufacture. In-line injection and tank blenders are considered acceptable methods for ensuring adequate mixing.

Table C-2 Other Detailed Requirements; SIP from Hydroprocessed fermented Sugargs

Sl No.	Characteristic	Requirement of SIP	Method of Test[1)] Ref to [P :] of IS 1448/IP/ASTM D
(1)	(2)	(3)	(4)
i)	*Hydrocarbon Composition:*		D7974
	a) Saturated Hydrocarbons, m/m percent, *Min*	98	
	1) Farnesane[2)], mass percent, *Min*	97	
	b) Hexahydrofarnesol[3)], mass percent, *Max*	1.5[4)]	
	c) Olefins, mg Br_2/100g, *Max*	300	D2710/IP299
	d) Aromatics, m/m percent, *Max*	0.5	D2425
	e) Carbon and Hydrogen, m/m percent *Min*	99.5	D5291
ii)	*Non-hydrocarbon Composition:*		
	a) Nitrogen, mg/kg, *Max*	2	D4629 or IP 379
	b) Water, mg/kg, *Max*	75	D6304 or IP 438
	c) Sulfur, mg/kg, *Max*	2	D5453 or D2622[5)]
	d) Metals (Al, Ca, Co, Cr, Cu, Fe, K, Mg, Mn, Mo, Na, Ni, P, Pb, Pd, Pt, Sn, Sr, Ti, V, Zn), mg/kg, *Max*	0.1 per metal	D7111 or UOP 389
	e) Halogens, mg/Kg, *Max*	1 per halogen	D7359

NOTES:

1 For additional alternate test methods refer Annex G

2 Farnesane is an iso-paraffin with chemical formula: $C_{15}H_{32}$, chemical name: 2,6,10-trimethyldodecane and CAS Registry Number: 3891-98-3.

3 Hexahydrofarnesol is an alkyl alcohol with chemical formula: $C_{15}H_{32}O$, chemical name: 3, 7, 11-trimethyl-1-dodecanol and CAS Registry Number: 6750-34-1.

4 The maximum level of hexahydrofarnesol is controlled by mass percent of hexahydrofarnesol below 1.5 percent, which represents a maximum of 0.11 percent by mass of remaining alcohol moieties brought by hexahydrofarnesol in the grade.

5 Sulphur content can be quantified by Test Method D2622 by certain laboratories with a lower detection limit of 1 mg/kg. In case of dispute, Test Method D5453 will apply.

ANNEX D

SYNTHESIZED KEROSENE WITH AROMATICS DERIVED BY ALKYLATION OF LIGHT AROMATICS FROM NON-PETROLEUM SOURCES

D-1 SCOPE

D-1.1 This annex defines FT Synthesized Paraffinic Kerosene plus Aromatics (SPK/A) for use as a synthetic blending component in aviation turbine fuels for use in aircraft gas turbine engines designed to operate on such fuel. The specifications in this Table D-1 and D-2 are to be used for contractual exchange of synthetic blending components. The difference between this Annex and Annex A is that Annex A is restricted to materials derived from FT processing having low aromatics content, whereas this annex describes streams where the aromatics content is intentionally increased by alkylation of non-petroleum derived light aromatics (primarily benzene) with Fischer-Tropsch-derived olefins.

D-1.2 The synthetic blending components defined in this Annex cannot be used for aviation turbine engines unless blended with conventional fuel or conventional blending components in accordance with the limitations described in **3.2.2**.

D-2 TERMINOLOGY

D-2.1 Fischer-Tropsch Hydroprocessed Synthesized Paraffinic Kerosene Plus Aromatics (FT-SPK/A), *n*—Fischer-Tropsch Synthesized Paraffinic Kerosene plus aromatics, produced by alkylation of nonpetroleum derived light aromatics (primarily benzene).

D-3 COMPOSITION

SPK/A synthetic blending component shall be comprised of FT SPK as defined in Annex A combined with synthesized aromatics from the alkylation of non-petroleum derived light aromatics (primarily benzene). Subsequent processing of the product shall include hydroprocessing, fractionation, and other conventional refinery processes.

D-4 BATCH REQUIREMENTS

Each batch of synthetic blending component shall conform to the requirements prescribed in Table D-1.

D-5 OTHER DETAILED REQUIREMENTS

The FT SPK/A blend component shall meet the requirements of Table D-2. These requirements are intended to verify the control of processes during the initial production scale-up of these synthetic blend components. However, Table D-2 requirements are further required only when new production facilities or schemes are established, or when significant changes to existing production operations are implemented, such as the introduction of a new feedstock material.

NOTE — It is the ultimate objective of this specification authority to transition these batch requirements to a management of change requirement once sufficient production experience is gained.

Table D-1 Detailed Batch Requirements; FT-SPK/A[1]

(*Clause* D-4)

Sl No.	Characteristic	Requirement for FT-SPK/A[1]	Method of Test[2] Ref to [P :] of IS 1448/IP/ASTM D
(1)	(2)	(3)	(4)
i)	*Composition:*		
	a) Acidity, total mg KOH/g, *Max*	0.015	[P : 113][2]/IP 354/ASTM D3242
	1) Aromatics, v/v percent, *Max*	20	[P : 23][2]/IP 156/ASTM D 1319
	2) Total Aromatics, v/v percent, *Max*	21.2	D6379/IP436
ii)	*Volatility:*		
	a) Distillation-both of the following requirements shall be met:		[P : 18][3],[2]/D86[3] or IP 123[3]
	1) Physical Distillation		
	Distillation temperature, °C:		
	i) 10 percent recovered, temperature (T10) *Max*	205	
	ii) 50 percent recovered, temperature (T50)	report	
	iii) 90 percent recovered, temperature (T90)	report	

Table D-1 *(Concluded)*

Sl No.	**Characteristic**	**Requirement for FT-SPK/A**[1]	**Method of Test**[2] **Ref to [P :] of IS 1448/IP/ASTM D**
(1)	**(2)**	**(3)**	**(4)**
	iv) Final boiling point, temperature *Max*	300	
	v) T90-T10, °C *Min*	22	
	vi) Distillation residue, percent *Max*	1.5	
	vii) Distillation loss, percent *Max*	1.5	
	2) Simulated Distillation		D2887
	Distillation temperature, °C:		
	i) 10 percent recovered, temperature (T10)	report	
	ii) 50 percent recovered, temperature (T50)	report	
	iii) 10 percent recovered, temperature (T10)	report	
	iv) Final boiling point, temperature	report	
(iii)	*Flash point, °C, Min*	38[4]	[P : 20][2]/ISO 13736/IP 170
(iv)	*Density at 15 °C, kg/m^3*	755 to 800	[P : 16][2]/IP 160/D 4052/D 1298/ IP 365
(v)	*Freezing point, °C, Max*	-40	[P : 11][2]/IP 16/D 2386/D 5972/ IP435/D7153/IP 529/D 7154/ IP 528
(viii)	*Thermal Stability (2.5 h at control temperature)*		
	a) Temperature. °C, *Min*	325[5]	[P : 97]/D3241[2]/IP 323
	b) Filter pressure drop, mm Hg, *Max*	25	
	c) Tube rating: One of the following requirements shall be met:[6]		
	1) Tube rating, visual(VTR)	<3 No peacock or abnormal color deposits	
	or		
	2) ITR or ETR, average over area of 2.5 mm^2, nm, *Max*	85	
(ix)	*Contaminants*		
	a) Existent gum, mg/100 ml, *Max*	4	P : 29[2]/D381/IP540
	b) MSEP, *Min.*	90	P : 142[2]/ASTM D 3948
(x)	*Additives*		
	a) Antioxidants, mg/l [7]	17 to 24	

NOTES:

1 Test results shall not exceed the maximum or be less than the minimum values specified in Table 1, Table D-1 and D2.

2 Denotes referee method in case of dispute. For additional alternate test methods refer Annex G.

3 [P : 18], D86 or IP123 distillation of jet fuel is run at Group 4 conditions, except Group 3 condenser temperature is used.

4 A higher or lower minimum flash point specification may be agreed upon between purchaser and supplier. When the agreed flash point is less than 38 °C then the product shall not known as SPK or as kerosene, but may be used as D blending component.

5 Control temperature of 325 °C is specified to provide a recurring, batch-by-batch verification of process stability and compositional consistency.

6 Tube deposit ratings shall be measured by D3241 Annex A2 ITR or Annex A3 ETR, when available. If the Annex A-2 ITR device reports "N/A" for a tube's volume measurement, the test shall be a failure and the value reported as >85 nm. Visual rating of the heater tube by the method D3241 Annex A1 is not required when Annex A2 ITR or A3 ETR deposit thickness measurements are reported. In case of dispute between result from visual and metrological methods, the referee shall be considered of the Annex A3 ETR method if available, otherwise Annex A2 ITR.

7 Antioxidant shall be added to the bulk product prior to movements or operations that will significant expose the product to air and in such a way as to ensure adequate mixing. This shall be done as soon as practicable after hydroprocessing and fractionation to prevent peroxidation and gum formation after manufacture. In-line injection and tank blenders are considered acceptable methods for ensuring adequate mixing.

Table D-2 Other Detailed Requirements; FT-SPK/A

(*Clause* D-5)

Sl No.	**Characteristic**	**Requirement**	**Method of Test**[1)] **Ref to [P :] of IS 1448/IP/ASTM D**
(1)	(2)	(3)	(4)
i)	*Hydrocarbon Composition:*		D2425
	a) Cycloparaffins, m/m percent, *Max*	15[2)]	
	b) Aromatics, m/m percent, *Max*	20	
	c) Paraffins, m/mass percent	report	
	d) Carbon and Hydrogen, m/m percent, *Min*	99.5	D5291
ii)	*Non-hydrocarbon Composition:*		
	a) Nitrogen, mg/kg, *Max*	2	D4629/IP 379
	b) Water, mg/kg, *Max*	75	D6304/IP 438
	c) Sulfur, mg/kg, *Max*	15	D5453/D 2622/ISO 13032
	d) Metals (Al, Ca, Co, Cr, Cu, Fe, K, Mg, Mn, Mo, Na, Ni, P, Pb, Pd, Pt, Sn, Sr, Ti, V, Zn), mg/kg, *Max*	0.1 per metal	UOP 389/D7111
	e) Halogens, mg/Kg, *Max*	1	D7359

NOTES:

1 For additional alternate test methods refer Annex G.

2 Maximum cycloparaffin composition is based on current experience with the approved synthetic fuels and is within the range of what is typical for refined jet fuel.

ANNEX E

ALCOHOL-TO-JET SYNTHETIC PARAFFINIC KEROSENE (ATJ-SPK)

E-1 SCOPE

E-1.1 This Annex defines alcohol-to-jet synthetic paraffinic kerosene (ATJ-SPK) as a synthetic blending component for aviation turbine fuels for use in aircraft gas turbine engines designed to operate on such fuel. The specifications in Table E-1 and E-2 are to be used for contractual exchange of synthetic blending components.

E-1.2 The synthetic blending components defined in this Annex cannot be used for aviation turbine engines unless blended with conventional fuel or conventional blending components in accordance with the limitations as described in **3.2.2**.

E-2 TERMINOLOGY

E-2.1 Alcohol-to-jet synthetic paraffinic kerosene (ATJSPK), n, — An SPK produced starting from alcohol and processed through the following steps: dehydration, oligomerization, hydrogenation, and fractionation.

E-3 COMPOSITION

The ATJ-SPK synthetic blending components shall be comprised of hydroprocessed synthesized paraffinic kerosene wholly derived from ethanol or isobutanol processed through dehydration, oligomerization, hydrogenation, and fractionation.

NOTE — It is the ultimate objective of this Specification Authority to permit use of all **C-2** to **C-5** alcohols for production of ATJ-SPK once sufficient test data is available for these other alcohols.

E-4 BATCH REQUIREMENTS

Each batch of synthetic blending component shall conform to the requirements prescribed in Table E-1.

E-5 OTHER REQUIREMENTS

The ATJ SPK blend component shall meet the requirements of Table E-2. These requirements are intended to verify the control of processes during the initial production scale-up of these synthetic blend components. However, Table E-2 requirements are further required only when new production facilities or schemes are established, or when significant changes to existing production operations are implemented, such as the introduction of a new feedstock material.

NOTE — It is the ultimate objective of this specification authority to transition these batch requirements to a management of change requirement once sufficient production experience is gained.

Table E-1 Detailed Batch Requirements; Alcohol-to-Jet (ATJ-SPK)[1]

(*Clause* E-4)

Sl No.	Characteristic	Requirement of ATJ-SPK	Method of Test[2] Ref to [P :] of IS 1448/IP/ASTM D
(1)	(2)	(3)	(4)
i)	*Composition:*		
	a) Acidity, total mg KOH/g, *Max*	0.015	[P : 113][2]/IP 354/D3242
ii)	*Volatility:*		
	a) Distillation-both of the following requirements shall be met:		[P : 18][3),2)]/D86[3]/D 7345/IP 123[3]
	1) Physical Distillation		
	Distillation temperature, °C:		
	i) 10 percent recovered, temperature (T10), *Max*	205	
	ii) 50 percent recovered, temperature (T50)	report	
	iii) 90 percent recovered, temperature (T90)	report	
	iv) Final boiling point, temperature, *Max*	300	
	v) T90-T10, °C, *Min*	21	
	vi) Distillation residue, percent, *Max*	1.5	
	vii) Distillation loss, percent, *Max*	1.5	

Table E-1 *(Concluded)*

Sl No.	Characteristic	Requirement of ATJ-SPK	Method of Test[2] Ref to [P :] of IS 1448/IP/ASTM D
(1)	(2)	(3)	(4)
iii)	*Flash point, °C, Min*	38[4]	[P : 20][2]/ISO 13736/IP 170/IP 523/ D 3828
iv)	*Density at 15 °C, kg/m³*	730 to 770	[P : 16][2]/D1298/IP 160/D 4052/ IP 365
v)	*Freezing point, Max*	-40	[P : 11][2]/D5972/IP 435 D7153/ IP 529/IP 16/ D7154/IP 528/D2386
vi)	*Thermal Stability (2.5 h at control temperature):*		
	Temperature. °C *Min*	325 [5]	[P : 97]/D3241[2]/IP 323[6]
	a) Filter pressure drop, mm Hg, *Max*	25	
	b) Tube rating: One of the following requirements shall be met:[7]		
	1) Tube rating, visual(VTR)	<3, No peacock or abnormal color deposits	
	or		
	2) ITR or ETR, average over area of 2.5 mm², nm, *Max*	85	
vii)	*Additives:*		
	a) Antioxidants, mg/L[8]	17-24	

NOTES:

1 Test results shall not exceed the maximum or be less than the minimum values specified in Table 1, Tables E-1 and E-2.

2 Denotes referee method in case of dispute. For additional alternate test methods refer Annex G.

3 [P : 18], D86 or IP 123 distillation of jet fuel is run at Group 4 conditions, except Group 3 condenser temperature is used.

4 A higher or lower minimum flash point specification may be agreed upon between purchaser and supplier. When the agreed flash point is less than 38 °C then the product shall not be known as SPK or as kerosene, but may be used as an Annex E blending component.

5 Control temperature of 325 °C is specified to provide a recurring, batch-by-batch verification of process stability and compositional consistency.

6 D3241/IP 323 Thermal Stability is a critical aviation fuel test, the results of which are used to assess the suitability of jet fuel for aviation operational safety and regulatory compliance. The integrity of D3241/IP 323 testing requires that heater tubes (test coupons) meet the requirements of D3241 Table 2 and give equivalent D3241 results to the heater tubes supplied by the original equipment manufacturer (OEM).

7 Tube deposit ratings shall be measured by D3241 Annex ITR or Annex ETR, when available. If the Annex ITR device reports “N/A” for a tube’s volume measurement, the test shall be a failure and the value reported as >85 nm. Visual rating of the heater tube by the method in D3241 Annex A1 is not required when Annex ITR or Annex ETR deposit thickness measurements are reported. In case of dispute between results from visual and metrological methods, the referee shall be considered the Annex ETR method if available, otherwise Annex ITR.

8 Antioxidant shall be added to the bulk product prior to movements or operations that will significantly expose the product to air and in such a way as to ensure adequate mixing. This shall be done as soon as practicable after hydroprocessing or fractionation to prevent peroxidation and gum formation after manufacture. In-line injection and tank blenders are considered acceptable methods for ensuring adequate mixing.

Table E-2 Other Detailed Requirements; Alcohol-to-Jet (ATJ-SPK)

(*Clause* E-5)

Sl No.	**Characteristic**	**Requirement of ATJ-SPK**	**Method of Test**[1)] **Ref to [P :] of IS 1448/IP/ASTM D**
(1)	(2)	(3)	(4)
i)	*Hydrocarbon Composition:*		D2425
	a) Cycloparaffins, m/m percent, *Max*	15[2)]	
	b) Aromatics, m/m percent, *Max*	0.5	
	c) Paraffins, m/m percent	report	
	d) Carbon and Hydrogen, m/m percent *Min*	99.5	D5291
ii)	*Non-Hydrocarbon Composition:*		
	a) Nitrogen, mg/kg, *Max*	2	D4629 or IP 379
	b) Water, mg/kg, *Max*	75	D6304 or IP 438
	c) Sulfur, mg/kg, *Max*	15	D5453/D2622/ISO 13032
	d) Metals (Al, Ca, Co, Cr, Cu, Fe, K, Mg, Mn, Mo, Na, Ni, P, Pb, Pd, Pt, Sn, Sr, Ti, V, Zn), mg/kg, *Max*	0.1 per metal	D7111 or UOP 389
	e) Halogens, mg/Kg, *Max*	1 per halogen	D7359

NOTES:

1 For additional alternate test methods refer Annex G.

2 Maximum cycloparaffin composition is based on current experience with the approved synthetic fuels and is within the range of what is typical for refined jet fuel.

ANNEX F

[*Table* 1, *Sl No.* (vi) b)]

DETERMINATION OF CORROSIVENESS TO SILVER OF AVIATION TURBINE FUELS — SILVER STRIP METHOD (ADOPTED FROM IP 227/99)

F-1 SCOPE

The test procedure specifies a method for the determination of the corrosive tendencies towards silver, of aviation turbine fuels. The result is classified as an integer in the range 0 to 4.

F-2 DEFINITION

F-2.1 Silver Corrosion

The corrosiveness of a sample, on a silver strip specimen, measured visually on a scale of 0 to 4.

F-3 PRINCIPLE

A polished silver strip is completely immersed in 250 ml of fuel at 50°C ± 1°C for a period of 4 h. At the end of this period the silver strip is removed from sample, washed and evaluated for corrosion.

F-4 APPARATUS

F-4.1 Test Apparatus

Comprising the following (*see* Fig. 1).

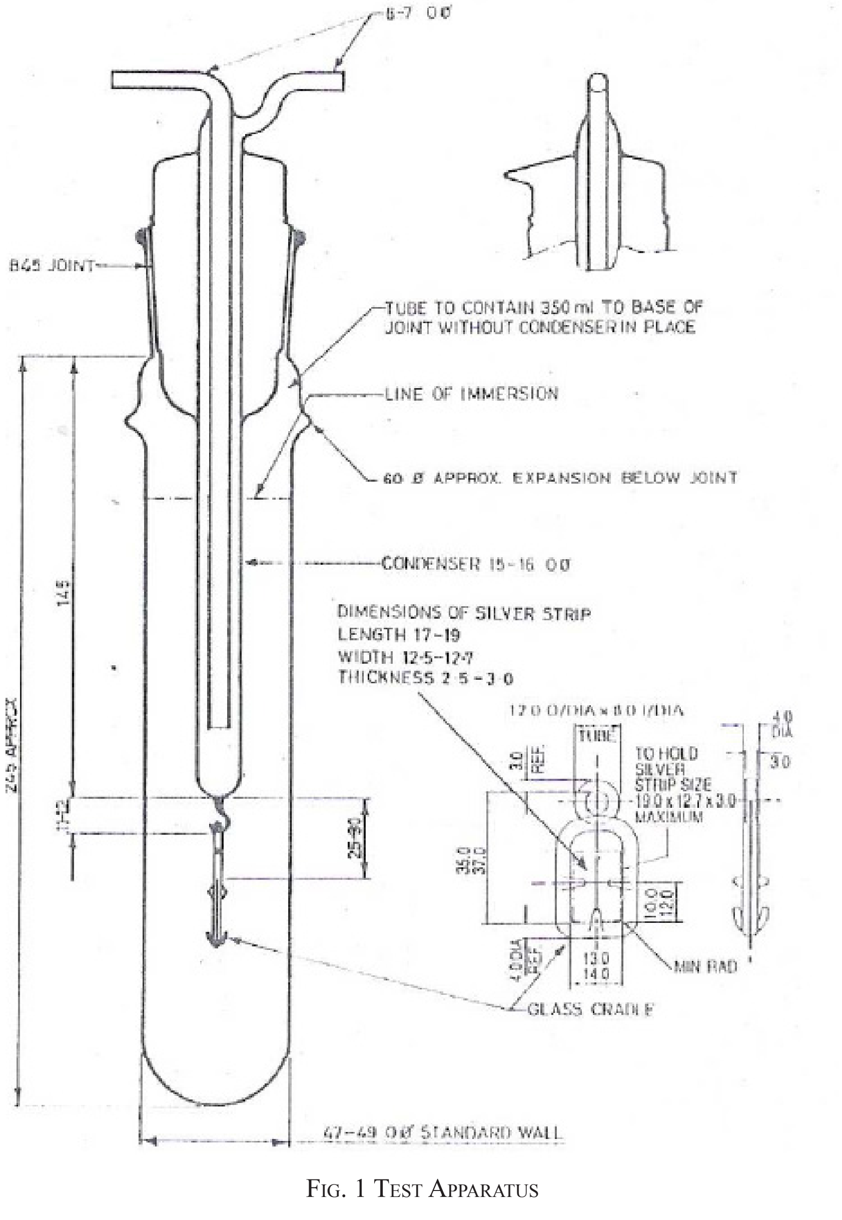

FIG. 1 TEST APPARATUS

F-4.1.1 *Test Tube*

350 ml capacity, made of heat-resistant amber glass and fitted with an amber glass B45 ground glass socket.

NOTE — Clear glass test tubes may be used provided light is excluded from the sample.

F-4.1.2 *Cold-finger Condenser*

Fitted through a B45 stopper such that an 85 mm length of the condenser is immersed in the fuel. The condenser shall be fitted with a glass hook from which the cradle is suspended. If more than one apparatus is in use, the condensers shall be connected in parallel so that each condenser has a similar efficiency. The inlet water temperature shall be controlled so that it does not exceed 25°C.

F-4.1.3 *Glass Cradle*

For suspension of the silver strip in the fuel such that the top of the strip is 25.0 mm to 30.0 mm below the bottom of the condenser.

F-4.2 Water Bath

Capable of maintaining the tube and its contents at a temperature of 50°C ± 1°C. The bath shall be fitted with a lid having holes to accommodate the test tubes.

F-4.3 Strip Vice

For holding he silver strip firmly without marring the edges.

NOTE — The type specified in ISO 2160, ASTM D130, IP 154 and BS 2000 : Part 154, is suitable.

F-4.4 Thermometer

Capable of indicating the temperature of the bath within the limits stated in **B-4.2** when immersed to its designated immersion. [Range -20 to + 102°C (LC - 0.2°C)].

NOTE — Thermometer of ASTM 12 C or IP 64 C grade can also be used.

F-4.5 Stainless Steel Forceps

F-5 REAGENTS AND MATERIALS

F-5.1 Silver strip, assaying at 99.9 percent (m/m) Ag minimum and of length 17.0 mm to 19.0 mm, width 12.5 mm to 12.7 mm, and thickness 2.5 mm to 3.0 mm.

F-5.2 Polishing materials, silicon carbide cloth of varying degrees of fineness including nominal 53 µm (240 grade); also a supply of nominal 105 µm silicon carbide grain and pharmaceutical grade absorbent cotton wool.

F-5.3 Filter paper, medium fast to fast.

F-5.4 2,2,4-trimethylpentane (isooctane) of minimum 99.75 percent purity is the referee solvent, but any volatile sulphur-free hydrocarbon solvent that shows no tarnish when tested by the procedure of this standard is suitable.

F-6 SAMPLING

Unless otherwise specified, the samples shall be taken by the procedures specified in ISO 3170. The bottle shall be fitted with an impervious gas tight closure and closed immediately after filling. The volume of the sample drawn shall be such that a maximum ullage of 5 percent remains in the container after filling.

F-6.1 Sample Handling

Keep the sample cool whilst being transported and stored.

NOTE — A maximum temperature of 4°C is recommended.

The sample shall be tested as soon as is practical after sampling and tested immediately after opening the sample container.

If suspended water (haze) is observed in the sample, obtain in alternative clear sample.

F-6.2 Apparatus Preparation

F-6.2.1 Do not use silver strips whose edges show wear (elliptical surfaces). Remove all surface blemishes from all six sides of the silver strip with silicon carbide cloth sufficiently fine to accomplish the desired results. Finish with nominal 53 µm (240 grade) silicon carbide cloth removing all marks that may have been made by other grades of cloth. Immerse the strip in the 2,2,4 – trimethylpentane, from which it shall be withdrawn when proceeding to the final polishing step.

F-6.2.2 As a practical manual procedure for surface preparation, either place a sheet of the abrasive cloth on a flat surface, moisten it with the 2,2,4 – trimethyl pentane, and rub the strip against the cloth with a rotary motion, protecting the strip from alternatively, prepare the strip mechanically, using appropriate grades of cloth.

F-6.2.3 Remove a strip from the 2,2,4 – trimethyl pentane. Holding it in the fingers protected with filter-paper, polish the ends and then the sides with the nominal 105 µm silicon carbide grains picked up from a clean glass plate with a pad of cotton wool moistened with a drop of the 2,2,4 – trimethyl pentane. Wipe vigorously with fresh pads of cotton wool and subsequently handle only with stainless steel forceps; do not touch with the fingers. Clamp in the vice and polish the main surfaces with the silicon carbide grains on cotton wool. Rub in the direction of the long axis of the strip, carrying the stroke beyond the end of the strip before reversing the direction. Clean all metal dust from the strip by rubbing vigorously with clean pads of cotton wool until a fresh pad remains unsoiled. Immerse the strip in the sample within 1 min of completing the final polishing.

NOTES:

1 It is important to polish the whole surface of the strip uniformly to obtain a uniformly stained strip. The use of a vice facilitates uniform polishing.

2 Contact of the silver strip with water before, or after, completion of the test run, will cause staining, making it difficult to evaluate the strip.

F-7 PROCEDURE

F-7.1 Pour 250 ml of the sample into the clean test tube. Suspend a freshly polished strip from the hook on the condenser by means of the glass cradle. Carefully lower the strip and condenser into the sample.

F-7.2 Place the tube in the water bath and maintain the temperature at 50°C ± 1°C for 4 h. During the test period, run water through the condenser at a temperature not exceeding 25°C and at a rate of 10 ml/min to induce thermal stirring. At the end of the test period remove the strip from the tube and immerse it in 2,2,4 – trimethyl pentane. Withdraw the strip immediately, dry it with filter paper (by blotting not wiping), and inspect it for evidence of corrosion.

Silver Strip Classification

Classification	*Designation*	*Description*
0	No tarnish	Identical to a freshly polished strip, but may have some very slight loss of luster
1	Slight tarnish	Faint brown or white discoloration of strip
2	Moderate tarnish	Peacock colours such as blue or mauve or medium/ dark straw or brown coloration
3	Slight blackening	Spots and patches of black or grey on surface or uniform thin film of black deposit
4	Blackening	Uniform heavy blackening with or without scaling

F-8 EXPRESSION OF RESULTS

F-8.1 Interpret the corrosiveness of the sample by comparing the appearance of the test strip with a freshly polished one to give a classification based on that given in Table above. All surfaces, including the edges, shall be taken into account.

F-8.2 The ASTM colour standard for the thermal oxidation stability of turbine fuels (ISO 6249/IP 323/ ASTM D 3241) shall be used to differentiate between the brown colorations mentioned in classifications 1 and 2. Any brown coloration less than ASTM No.4 shall be rated classification 1.

F-9 REPORT

The test report shall include:

a) The type and identification of the product tested;
b) A reference to this standard;
c) The result of the test (**F-8**);
d) Any deviation, by agreement or otherwise, from the standard procedures specified; and
e) The date of the test.

F-10 PRECISION

The precision of this method is as follows:

a) Repeatability, r = 0; and
b) Reproducibility, R = 1.

The precision values, as defined in ISO 4259/BS 4306 : 1992/IP 367, have been obtained by statistical examination of inter-laboratory results. (9 laboratories on 5 samples covering the results range 0 to 3), and were first published in 1971. A precision evaluation report is held at the Institute of Petroleum.

NOTE — In deriving these precision values, it was assumed that all the variability in the results reflected the precision of the method and was not due to any change in the samples between tests.

ANNEX G

(*Foreword*)

ALTERNATE TEST METHODS

Characteristic	*Alternate Method of Test*
Appearance	ASTM D 4176 Procedure 1
Total sulphur	ISO 4260, ISO 14596, ASTM D 1266, ASTM D 1552, ASTM D 2622, ASTM D 5453, IP 107, IP 373, IP 447, IP 336, ISO 20846, ISO 20884/ISO 13032
Flash point	ASTM D 56 (Note 2), IP 523, ASTM D3828
Density at 15°C	ISO 12185, ASTM D 1298, IP365,ISO 3675
Freezing point	IP 435/ASTM D 5972, IP 528, IP 529/ASTM D 7153, ASTM D 7154 IP16,
Specific energy	ASTM D 4809, IP 12, IP 355
Distillation	ASTM D 7345(*see* Note 1), ISO 3405
Kinematic viscosity	ASTM D 7042 (*see* Note 2), ISO 3104
Smoke point	ASTM D 1322,ISO 3014
Cu strip corrosion	ISO 2160
JFTOT	ISO 6249
FAME	IP 583, D 7797, IP 599

NOTE:

1 Results from Test Method ASTM D7345 shall be corrected for relative bias as described in Test Method ASTM D7345.

2 Test Method ASTM D7042 results shall be converted to bias-corrected kinematic viscosity results by the application of the correction described in Test Method ASTM D7042 for jet fuel at -20°C as described in the precision and bias section.

ANNEX H

(*Clause* 3.2.5.1)

AVIATION TURBINE FUEL LUBRICITY

(*Informative*)

H-1 Aircraft/engine fuel system components and fuel control units rely on the fuel to lubricate their moving parts. The effectiveness of a jet fuel as a lubricant in such equipment is referred to as its 'lubricity'. Differences in component design and materials result in varying degrees of equipment sensitivity to fuel lubricity. Similarly, jet fuels vary in their level of lubricity. In-service problems experienced have ranged in severity from reductions in pump flow to unexpected mechanical failure leading to in-flight engine shutdown.

H-2 The chemical and physical properties of jet fuel cause it to be a relatively poor lubricating material under high temperature and high load conditions. Severe hydroprocessing removes trace components resulting in fuels which tend to have a lower lubricity than straight-run or wet-treated fuels. Lubricity improver additives are widely used in military jet fuels. They have been used occasionally in civil jet fuel to overcome aircraft problems, but only as a temporary remedy while improvements to the fuel system components or changes to fuel were achieved. Because of their polar nature, these additives can have adverse effects on ground-based filtration systems and on fuel/water separation characteristics.

H-3 Some modern aircraft fuel system components have been and are being designed to operate on poor lubricity fuel. With the participation of the international aviation industry the SAE AE-5B group has revised the procedure for the low lubricity endurance test for aircraft engine fuel pumps, ARP 1797. The procedure now specifies that the test fluid used shall produce a wear scar diameter (wsd) between 0.85 and 0.96 mm as measured by ASTM D 5001. The introduction of a lubricity requirement maximum of 0.85, mm wsd is to provide a limit to the fuel lubricity which attempts to ensure that future equipment proven against ARP 1797 procedure does not suffer lubricity related problems in use. The requirement only applies to fuels containing more than 95 percent hydroprocessed material where at least 20 percent is severely hydroprocessed. All the fuels which have caused problems have been in this category. It has been noted that not all fuels containing severely hydroprocessed components produce a wsd greater than 0.85 mm and this has been taken into account in setting the requirement.

H-4 There are older fuel system components still in use which are more sensitive to fuel lubricity. In these cases the aircraft operator should consult with the equipment manufacturer and fuel supplier to determine the best course of action which may induce the use of an approved lubricity additive to enhance the lubricity of a particular fuel, a measure which is already permitted by the standard.

ANNEX J

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ANNEX K

(*Foreword*)

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